MEMORANDUM:

DATE: September 3, 1998

SUBJECT: Catalyst Control Cost Information

FROM: Reciprocating Internal Combustion Engine Work Group

TO: ICCR Coordinating Committee

The Reciprocating Internal Combustion Engine Work Group (RICE WG) made an effort to gather control cost information for add-on control devices which utilize oxidation, due to their potential for HAP reduction. The RICE WG concurs that this information may be valuable to EPA in developing MACT regulations for RICE and requests that the ICCR Coordinating Committee forward it to EPA as a Work in Progress Item.

Two types of catalysts were identified: non-selective catalytic reduction (NSCR), and oxidation catalysts. Several catalyst manufacturers were contacted to provide cost information. This information is included as Attachment I, with the control device vendors' names removed for confidentiality reasons. The cost figures provided by the control device vendors during this preliminary request were inadequate for the purposes of conducting a cost effectiveness evaluation. The RICE WG believes that the wide range of costs is due to misinterpretation of the cost request. The RICE WG believes that the cost quotes provided as $/HP were not appropriate since some costs are fixed, such as the cost of an air-to-fuel controller, while other costs depend on HP, exhaust flowrate, and exhaust temperature.

It was decided by the RICE WG that a more detailed request would be sent out to the two vendors who had responded positively to the first request. This request is included as Attachment II.

In addition to the model engine information provided in Attachment II, the control device manufacturers requested that the WG provide as much information on exhaust parameters (flow rate, temperature) as possible. This is in the process of being gathered from engine manufacturers, and passed on to the catalyst control device vendors.

The RICE WG encourages EPA to continue to pursue this cost information in their evaluation of cost effectiveness.

Attachments: 1: Preliminary Control Cost Request Summary
2: Follow-up Control Cost Request Letter

Attachment I

Preliminary Control Cost Request Summary

Preliminary Control Cost Information for IC Engines - All in 1998 $s

Control Device: NSCR
Manufacturer: A

Emissions Reduction: CO 90 - 95%; NOx 80 - 95%

Engine Size (HP)	COST ($/HP)
150	25
151 - 750	15 - 25
751 - 1500	13 - 15
1501 - 2000	8 - 12

Notes:
- Typical Catalyst Life 2 to 4 yrs
- Costs includes Installation
- Operating costs for NSCR are nil

Control Device: NSCR
Manufacturer: B

Emissions Reduction:
Option 1: 90+%; NOx, CO, HC @ 2, 2, 1 grams/HP, respectively 49 states

Engine Size (HP)	COST ($/HP)
515	17.33 (price includes an A/F controller)
978	11.22 (price includes an A/F controller)
2000	NA

Option 2: 99+%; Installing an additional reducing (oxidation) element for CO and HC
CO, HC @ 0.2 grams/HP 49 states

Engine Size (HP)	COST ($/HP)
515	27.38 (price includes an A/F controller)
978	18.6 (price includes an A/F controller)
2000	NA

Option 3: For California - NOx, CO, HC @ 0.15, 0.6, 0.5 grams/HP

Engine Size (HP)	COST ($/HP)
515	24.76 (price includes an A/F controller)
978	22.49 (price includes an A/F controller)
2000	NA

Option 4: For California - Installing an additional reduction (oxidation) element for CO and HC

Engine Size (HP)	COST ($/HP)
515	42 (price includes an A/F controller)
978	31.6 (price includes an A/F controller)
2000	NA

Notes:

- Catalyst lifetime is 5 to 7 years and can be as high as 10 years if using clean fuel

Maintenance:

- Cleaning once every 3 yrs. Cleaning will take about 4 to 6 hrs
- Catalyst replacement cost is less than new catalyst cost, will provide data at a later time

Control Device: NSCR - DeNOx Silencer
Manufacturer: C

Emissions Reduction: NOx 90%, NMHC 70%

Engine Size (HP)	COST ($/HP)
200	57 (price includes A/F controller and apparatus)
201 - 1000	52 (price includes A/F controller and apparatus)
1001 - 2000	42 (price includes A/F controller and apparatus)
2001+	38 (price includes A/F controller and apparatus)

Notes:

- Catalyst life cycle is about 3 to 7 yrs

Maintenance:

- Annual catalyst cleaning; 2 to 4 hrs/yr (for engines less than 2000 HP), and 4 to 6

hours/yr (for engines greater than 2000 HP)
- An oxygen sensor of $100 should be added.

Instrumentation Costs:
- About $5000 to $10000 for engines greater than 2000 HP, and about ½ of that for engines less than 2000 HP

Manufacturer: D
Control Device: NSCR

Emissions Reduction: 60 -80% formaldehyde

Engine Size (HP)	COST ($/HP)
any	5 - 10 (Does not include A/F controller)

- A/F controller is about $3000 to 6000 (low end unit to high end unit)

Installation:
- $2000 to $5000

Notes:
- Catalyst Life Cycle is about 5 yrs

Maintenance:
- Includes catalyst washing every 1 to 2 yrs ($4 to 7/HP)

Control Device: **CO Oxidation**
Manufacturer: **A**

Emissions Reduction: CO: 90 - 95%, Formaldehyde: 70%

Engine Size (HP)	COST ($/HP)
150	20
151 - 750	15 - 20
751 - 1500	10 - 15
1501 - 2000	10 - 11

Notes:
- Typical Catalyst Life
- Costs includes Installation
- Operating costs for CO oxidation are nil

Control Device: **CO Oxidation**
Manufacturer: **B**

Emission Reductions:
70% for formaldehyde, 99% other HAPs

Engine Size (HP)	COST ($/HP)	
538	39.58	T exhaust = 737 F (if T < 800 F, catalyst is more expensive)
1077	13.62	T exhaust = 845 F

Notes:
- Catalyst lifetime is 5 to 7 years and can be as high as 10 years if using clean fuel

Maintenance:
- Cleaning once every 3 yrs. Cleaning will take about 4 to 6 hrs

Other:
- Catalyst replacement cost is less than new catalyst cost, will provide data at a later time

Attachment II

Follow-up Control Cost Request Letter

August 21, 1998

Mr./Miss _____
_____
_____
_____
_____

SUBJECT: Catalyst Control Cost Information Request

Dear _____:

We would like your assistance in providing cost data for add-on controls for stationary reciprocating internal combustion engines (RICE). As discussed during the teleconference last week, the RICE Work Group put together a list of model engines for which they would like to gather control costs. This cost information will be used in developing MACT standards for RICE. The RICE Work Group has identified oxidation catalyst systems as potential hazardous air pollutants reduction technologies. This includes three way catalysts (NSCR) and CO oxidation catalysts.

Please provide cost information in 98 dollar figures for 90% reduction of CO and NOx, as well as the expected reduction for formaldehyde, for the attached list of model engines (Attachment A). The cost information that we are requesting for each model engine and control device include the following:

1- The Control Device and Auxiliary Equipment Cost (EC).
- This cost should not include instrumentation, tax, freight, and installation.

2- Direct Annual Cost (DAC).
- This cost should include utilities; operating labor; maintenance; and catalyst cleaning, replacement, and disposal. Please provide details/basis for each of these costs.

3- Expected Fuel/Energy Penalty

4- Equipment life (n).
- Please provide equipment life for the catalyst system (insert and housing) and for the catalyst insert separately.

5- Your feedback regarding the applicability of the assumptions made in the cost methodology for NSCR and CO-oxidation catalysts. Please provide your input regarding the applicability and accuracy of the assumed percentages listed in the table provided in Attachment B.

The control cost data will be used in evaluating cost effectiveness of such controls on a $ per ton of HAPs reduced basis. EPA is planning to use the Office of Air Quality Planning and Standards (OAQPS) Control Cost Manual (CCM) in conducting this evaluation. A copy of the CCM cost methodology and its assumptions is included as Attachment C for your reference.

We understand that the control costs are affected by the exhaust parameters. If you would like assistance in gathering exhaust parameters for these engines, we can attempt to contact members of the EMA who are also on the RICE Work Group for this information. In addition, please indicate the time frame under which we can expect these costs. Thank you for your assistance with this task. Feel free to call either Brahim Richani or myself if you have any questions or concerns, at 919-954-0033. You may also contact Amanda Agnew of the EPA at 919-541-5268.

Sincerely,

Jennifer R. Snyder
Chemical Engineer

cc: Amanda Agnew, US EPA, ESD, MD-13

ATTACHMENT A

List of Model Engines

SUMMARY LIST OF MODEL ENGINES

2SLB SIGF

NA:	AJAX DPC 140	115 HP
	CLARK RA6	600 HP
	COOPER BESSEMER GMV10	1100 HP
TA:	COOPER BESSEMER GMV10TC	1350 HP
	COOPER BESSEMER 10V250	3800 HP
	WORTHINGTON ML20	7500 HP

4SLB SIGF

NA:	CATERPILLAR 3306	250 HP
	WAUKESHA 7042 GL	1478 HP
	CATERPILLAR 3512	1000 HP
TA:	CATERPILLAR 3512	1220 HP
	COOPER BESSEMER LSV16G	5200 HP

4SRB SIGF

NA:	CATERPILLAR G3408	255 HP
	WAUKESHA 7042G	1024 HP
TA:	CATERPILLAR G3306	67 HP
	CATERPILLAR G3408	300 HP
	WAUKESHA L7042 GSI	1478 HP
	WAUKESHA F3521 GSI	738 HP

4SLB CILF

NA:	CUMMINS 4B3.9	66 HP
	CATERPILLAR D399	750 HP
TA:	CUMMINS 4BT3.9	100 HP
	CUMMINS KTA50	1850 HP

2SLB CILF

NA:	DETROIT 4-53	80 HP
	DETROIT 16V71	510 HP
TA:	DETROIT 4-71	191 HP
	DETROIT 16V149	1965 HP
	DETROIT 12V92	818 HP

NOTES:

- 2SLB SIGF means 2 stroke, lean burn, spark ignited, gaseous fuel.
- 4SLB SIGF means 4 stroke, lean burn, spark ignited, gaseous fuel.
- 4SRB SIGF means 4 stroke, rich burn, spark ignited, gaseous fuel.
- 4SLB CILF means 4 stroke, lean burn, compression ignited, liquid fuel.
- 2SLB CILF means 2 stroke, lean burn, compression ignited, liquid fuel.
- NA means natural aspiration.
- TA means turbo aspiration.

ATTACHMENT B

OAQPS CCM Cost Parameters Assumptions

Cost Methodology Assumptions

Cost Parameter	Assumed Percentage of Equipment Cost (EC)	Is Percentage Adequate?	Comments (If No)
Purchased Equipment Costs			
Instrumentation	10% of EC	Yes No	
Sales Tax	3% of EC	Yes No	
Freight	5% of EC	Yes No	
Direct Installation Costs			
Foundation and Support	9.4% of EC	Yes No	
Handling and Erection	16.5% of EC	Yes No	
Electrical	4.7% of EC	Yes No	
Piping	2.4% of EC	Yes No	
Insulation for Duct Work	1.2% of EC	Yes No	
Painting	1.2% of EC	Yes No	
Indirect Installation Costs			
Engineering	11.8% of EC	Yes No	
Construction and Field Expenses	5.9% of EC	Yes No	
Contractor Fees	11.8% of EC	Yes No	
Start-up	2.4% of EC	Yes No	
Performance Test	1.2% of EC	Yes No	
Contingencies			
Contingencies	3.5% of EC	Yes No	
Indirect Annual Costs			
Overhead	60% of Operating Labor and Maintenance	Yes No	
Property Taxes	1.9% of EC	Yes No	
Insurance	1.9% of EC	Yes No	
Administrative Charges	3.8% of EC	Yes No	

ATTACHMENT C

OAQPS CCM Cost Methodology

Control Costs
Utilize *OAQPS Control Cost Manual* methodology

Determine:

1 - Total Capital Costs
2 - Total Annual Costs
3 - Cost Effectiveness

1 - Total Capital Cost Components and Factors:

Total Capital Cost (TCC) = Direct Costs (DC) + Indirect Costs (IC)

1.1 - Direct Costs (DC): DC = PEC + DIC

1.1.1 - Purchased Equipment Costs (PEC):

- Control Device and auxiliary equipment (EC)
- Instrumentation (10% of EC)
- Sales Tax (3% of EC)
- Freight (5% of EC)

PEC = 118% EC

1.1.2 - Direct Installation Costs (DIC)

- Foundations and Supports (8% of PEC)
- Handling and Erection (14% of PEC)
- Electrical (4% of PEC)
- Piping (2% of PEC)
- Insulation for Ductwork (1% of PEC)
- Painting (1% of PEC)

DIC = 30% PEC

DC = PEC + 0.3 PEC = 1.3 PEC

1.2 - Indirect Costs (IC): IC = IIC + C

1.2.1 - Indirect Installation Costs (IIC)

- Engineering (10% of PEC)
- Construction and Field Expenses (5% of PEC)
- Contractor Fees (10% of PEC)
- Start-up (2% of PEC)
- Performance Test (1% of PEC)

IIC = 28% PEC = 0.28 PEC

1.2.2 - Contingencies (c) (3% of PEC)

- Equipment Redesign and Modifications
- Cost Escalations
- Delays in Startup

C = 3% PEC = 0.03 PEC

IC = 0.28 PEC + 0.03 PEC = 0.31 PEC

TCC = 1.3 PEC + 0.31 PEC = 1.61 PEC = 1.61 (1.18 EC) = 1.9 EC

2 - Total Annual Cost Elements and Factors

Total Annual Cost (TAC) = Direct Annual Costs (DC) + Indirect Annual Costs (IC)

2.1 - Direct Annual Costs (DC):

- Utilities
- Operating Labor
- Maintenance
- Annual Compliance Test
- Catalyst Cleaning
- Catalyst Replacement
- Catalyst Disposal

2.2 - Indirect Annual Costs (IC)

- Overhead (60% of Operating labor and maintenance costs)
- Fuel Penalty
- Property Tax (1% of TCC)
- Insurance (1% of TCC)
- Administrative Charges (2% of TCC)
- Capital Recovery =
  $((I(1+I)^n/(1+I)^n-1)*TCC)$ where I is the interest rate, and n is the equipment life

3 - Cost Effectiveness

- Measured in $/ton of pollutant removed
- Divide total annual cost by the annual tons of pollutant removed